DEFECTS IN STEAM BOILERS.

(With two-page engraving.)

The Austrian Society of Engineers and Architects several years ago appointed a committee to make an investigation of the subject of defects in steam boilers, their causes, consequences and methods of repair and prevention. The first report of that committee was made in 1891, and related to the defects of locomotive and portable boilers. The second report related to stationary boilers and is in the form of a quarto pamphlet of 49 pages of text, profusely illustrated, and 13 plates of photogravures. It is entitled "Schaden an Dampfkesseln. Heft II., Schaden an Stabilkesseln." The pamphlet is an excellent contribution to the literature of steam boilers, and is a fine example of what good work may be accomplished by a research committee of an engineering society when it takes plenty of time and infinite pains. Many of the forms of boilers shown in the report are unknown in American practice, some of them being survivals of ancient types which were never used here and are going out of use in Europe, while others are complicated new constructions, evidences of a transition stage of engineering in which the new forms of construction are apt to be more notable for their variety than for their excellence. Much of the material in the report, however, contains information which applies to the types of boilers built in this country. We have abstracted from the report those portions which we believe to be of most general interest, and have had them translated by Mr. O. J. Marstrand, M. Am. Soc. C. E. The defects are considered under the following heads: I. Change of Shape. II. Corrosions. III. Scratches, Cracks and Imperfections of Material. Examples of all of these kinds of defects, taken from photographs, are given in our inset sheet. We begin our extracts from the text with the subject of Corrosion; each extract being accompanied with a cut.

I.—External Corrosion. Figs. 1 to 6.

Fig. 1.—Local rust, spreading itself in tongue shapes over large surfaces.

Location.—Exterior surfaces of boiler, in places where the masonry forming the fire and draft passages touches the boiler shell.

Cause.—Water absorbed by the masonry. When the boiler is not steaming, water is condensed upon the lower drums, runs down, and gathers on the sides where the wall is built in against the drum.

Consequences.—Gradual destruction of such places; dangerous because the adjoining masonry makes inspection difficult.

Prevention.—Use clay mortar instead of lime mortar at these places; finishing by inserting a layer of asbestos; insertion of iron plates between wall and drum; draining of the bottom flue by deep drain pipes and water-seal. Frequent drying out of the flue by heat is recommended.

Fig. 2.—Rust on the plate-edges and rivet-heads.

Location.—On the first seams of the plates, but at a greater or less extent on all, and especially on inaccessible parts of the exterior surface of the boiler.

Cause.—In using very sulphurous coal there will be formed by its combustion both sulphurous acid, SO_2, and sulphuric anhydride acid, SO_3, which is changed by water vapor into sulphuric acid, H_2SO_4. Such vapor is made when the hot cinders are extinguished under the grate. There is an accumulation of this acid in the non-conducting covering of the exterior surface of the boiler, at the seams. The presence of lime in the boiler covering, however, neutralizes the acid and acts as a preventative of corrosion.

Consequences.—Soot and other ingredients of the coating on the exterior surfaces absorb the sulphuric anhydride, which is harmless, when the outside of the drum is dry; on cooling, however, it absorbs water from the air and is changed into sulphuric acid, which is corrosive. Weakening of the seams and plates, often dangerous at places which escape cleaning and examination.

Prevention.—Brushing the exterior surfaces of the drum before it is cooled. Drawing the cinders out of the ash pit before quenching them.

Fig. 3.—Rust on the plate joints.

Location.—Especially on the parts of the drum in the fire passages.

Cause.—The sulphuric acid, formed as stated above, acts to destroy the plate, especially when small leaks are present in the seams.

Consequence.—The corrosion in such places is much more rapid than ordinary rusting.

Prevention.—Immediate calking of leaky seams.

Fig. 4.—Rust on circular seams and in corners.

Location.—On the circular and longitudinal seams (less frequently on the seams) of the lower drum and on the bottom course of the outer shell of the fire tube boilers.

Cause.—Small leaks in the seams in the second or third fire passage where the flue gases are so cooled that they do not evaporate the accumulated moisture on the plate.

Consequence.—When limited to a small part of the circumference, not adjoining a point of support of the boiler, the rust may accumulate to several millimeters in depth without becoming dangerous. The calked edge of the seam is destroyed in such places; by continual leaking the shanks of the rivets will also be considerably corroded.

Prevention.—Careful riveting. Frequent inspection of these places, especially the rear parts of the under side of the drum, and all the intersections of the circular and longitudinal seams where the latter form a gathering place for moisture. Quick cooling of the boiler is to be avoided. Leaky seams should be calked immediately.

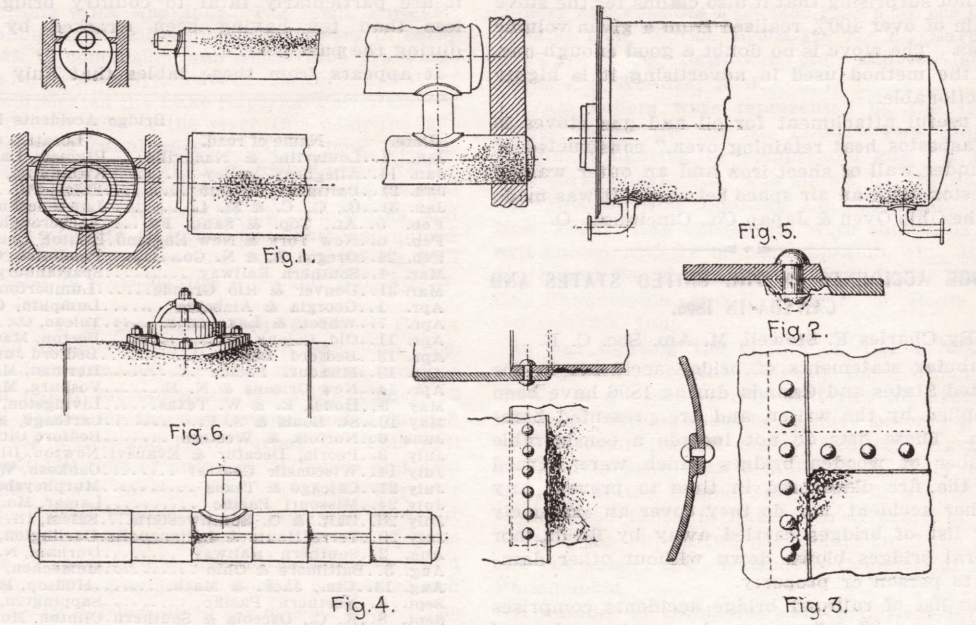
Fig. 5.—Rust at the edges of flanges joined to the boiler plates by bolts.

Location.—In places where the cast-iron flanges of the steam-pipe and feed-pipe are fastened to the drum.

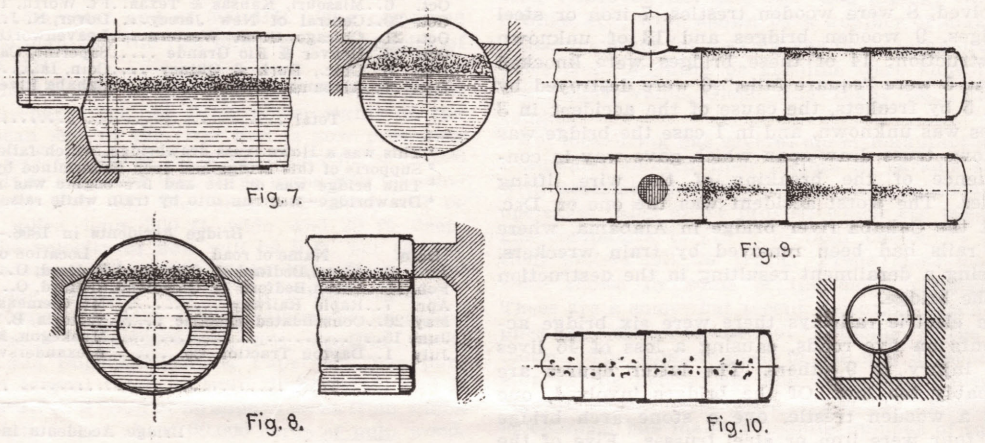
Cause.—Badly-fitting flanges. Defective riveting at parts which are difficult to reach.

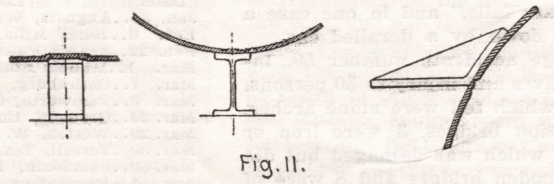
Consequence.—These places are difficult to inspect and are exposed to extensive corrosions on account of the surrounding masonry which spreads the moisture.

Prevention.—Flanges which are curved to fit the round-

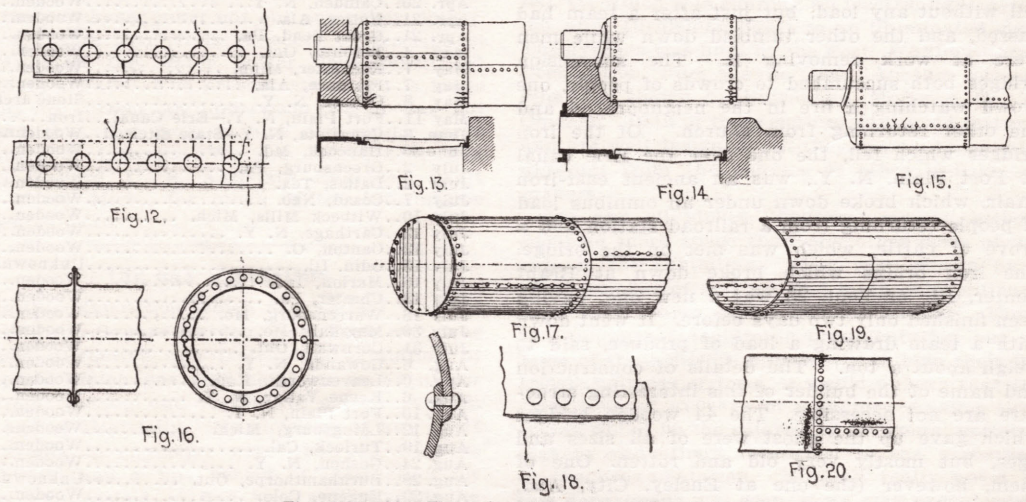


Figs. 1 to 6. Examples of External Corrosion.





Figs. 7 to 11.—Examples of Internal Corrosion.



Figs. 12 to 20.—Examples of Cracks and Ruptures.

SOME TYPICAL DEFECTS IN STEAM BOILERS.

Collected by a Committee of the Austrian Society of Engineers and Architects.

ing of the drum are to be carefully made and should be furnished with a wrought-iron packing ring.

Fig. 6.—Same kind of corrosion as shown in Fig. 5.

Location.—In places where flanges of cast-iron manhole frames are fastened to the boiler plates.

Cause.—Leakage, from defective riveting and calking of the flange.

Consequence.—Dangerous when extended over large surfaces, the process being favored by concealment by the masonry.

Prevention.—Cast-iron manhole frames are to be exactly worked and fitted and provided with packing rings. The riveting is to be kept clear of the masonry.

II.—Internal Corrosion. Figs. 7 to 11.

Fig. 7.—Burning of surfaces at the water level.

Location.—On the upper drum, immediately above the water level.

Cause.—Bad fitting of the masonry in the smoke passages, or the roof of the flame passages being placed too high in relation to the low water level, whereby the dry boiler plates are continually exposed to the fire.

Consequence.—The resulting corrosion produces, in a plane parallel to the longitudinal axis, dangerous weakening of the material which extends along the plates at the height of the water level. The plates are burned out and fall off on the inside as scales.

Prevention.—The top of the smoke passage must be 10 centimeters (4 ins.) below the low water level. The masonry is to be built with an upright course, cut to suit the curvature of the drum.

The limit-line for the masonry ought to be painted on the boiler by the maker.

Fig. 8.—Similar to Fig. 7.

Location.—On the rear drum head, especially in fire-tube and water-tube boilers.

Cause.—Bad fitting of the masonry to the end of the drum, whereby this part of the boiler is heated at places where it is not in contact with water.

Consequence.—Dangerous weakening of the material in a place where it is most yielding.

Prevention.—Sound and well-fitting brickwork at the rear head of the drum.

Fig. 9.—Burning away in the upper side of the water drum.

Location.—When too little inclination is given to the upper side of the lower drum, or when, by telescopic arrangement of the courses, the inside lap is placed in such a direction that it will trap or pocket the steam.

Cause.—Obstruction to the escape of the steam due to too slight inclination or to a projecting edge of the plate. There are formed tongue-shaped coatings on the surfaces which are much heated by the gases and by the radiation from the neighboring masonry.

Consequence.—The burning away of the plates, when limited to small surfaces, is not very dangerous. By longer-continued action the material is destroyed.

Prevent.on.—Proper arrangement of the rings and sufficient inclination of the lower drum (at least 1-50 of the length.)

Fig. 10.—Pittings or groovings on the inside of the boiler.

Location.—In places where drums rest on the masonry along the whole length.

Cause.—Alternate heating and cooling through variable feeding when the end of the feed-tube is too close to the metal of the boiler. Low temperature of the metal at this point which favors a longer retention of gases absorbed in the water (lack of circulation in the water).

Consequence.—The appearance of numerous corrosions which extend ribbon-shaped along the under side of the drum necessitates often the replacing of all the bottom plates or the complete renewal of the drum.

Prevention.—Drums resting upon masonry between the smoke passages are to be avoided.

Fig. 11.—Furrow-shaped corrosions on the inside of the boiler.

Location.—On places pressed inward, as above the supporting columns, behind the bearers, and under the upright tubes, especially on the cooler drums.

Cause.—Strains in the material resulting from the weight and the temperature changes.

Consequence.—As a rule, not dangerous, when discovered in time.

Prevention.—Suitable supports; protection of the corroded parts.

III.—Cracks and Ruptures. Figs. 12 to 20.

Fig. 12.—Cracks entending from the rivet holes.

1, single; 2, branched.

Location.—Cracks at the rivet holes which already have been formed during the manufacture may occur in any rivet seam. The formation of cracks at the rivet holes during the use of the boiler occurs especially on the parts exposed to the flame; more frequently at the round seams than at the longitudinal.

Cause.—Defective material; too hard metal; red-short or cold-short and badly-welded iron; defective manufacturing; badly-punched plates; holes not fitting and strained by use of a drift-pin; sudden changes in temperature.

Consequence.—A few short cracks at the rivet holes may lead to no further results; several cracks diminish the strength of the rivet seams. Long cracks produce leaks. Sudden bursting may occur. Rivet holes in parts under tension tear open and are on that account more dangerous than rivet holes in parts under compression where the cracks tend to close themselves.

Prevention.—Rivet holes are, when possible, to be drilled at the same time through both plates, after these are bent and fitted together.

Punching of the plates must be done with well-fitting, sharp dies, and the holes must be punched about 20% too small and then reamed out. Where burrs occur they must be cut off and the holes countersunk. Short cracks must be repaired by calking; long cracks by drilling a hole through the end of the crack and driving a rivet with a large head.

Fig. 13.—Similar to Fig 12.

Location.—In cylindrical boilers on the lower and unprotected half of the drumhead.

Cause.—The inflow of cold air, when the fire-door is open. The outside of the plate is more cooled than the inside and, therefore, contracts more. The alternate expansion and contraction of the material produces cracks.

Consequence.—The presence of numerous cracks in the rivet holes and the edges destroys the strength of the seam, which becomes leaky.

Prevention.—The first round seam must be sufficiently protected by the masonry. Closing of the damper before opening the fire-door. Open windows or doors immediately in front of the fire-doors should be avoided.

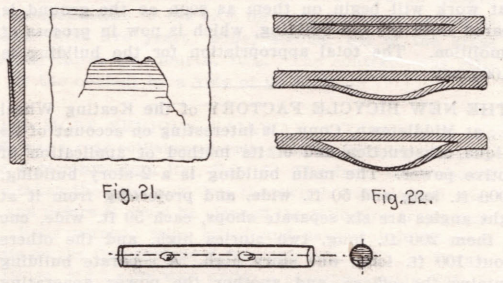


Fig. 21. Fig. 22.

Fig. 23.

Figs. 21 to 23.—Examples of Faulty Material in Steam Boilers.

Fig. 14.—Single, short cracks at the rivet holes in the round seams.

Location.—On the first round seam near the fire-bridge where it is exposed to the direct attack of the flame, as well by external as by internal firing.

Cause.—The flame causes superheating and considerable local strain. Badly-fitting rivet holes and rivets, whereby strains are set up in the material, favors the production of cracks.

Consequence.—The appearence of leaks as soon as the crack extends beyond the rivet head (long cracks). At first incrustation at the crack is noticed, then penetration of moisture, and finally, by larger leaks, streams of water.

Prevention.—The arrangement of round seams in the immediate neighborhood of the fire-bridge (especially immediately behind it) is to be avoided. Patching the fire-plates which are cracked at the rivet holes is not to be recommended. Such fire-plates should be renewed.

Fig. 15.—Cracks at the rivet holes in the longitudinal seams.

Location.—In long drum and in fire-tubes on the longitudinal seams above the grate.

Cause.—Superheating of the longitudinal seam by the flame and the radiation from the adjacent hot masonry, when external firing is used. Also, in fire-tubes, on account of superheating of the longitudinal seam by contact of the flame and the boiler plates, the conductivity of heat at the lap seam being decreased, and the outer plate cooled by the inflowing air.

Consequence.—Opening of the calked seam and leak in the riveting.

Prevention.—Suitable arrangement of the longitudinal seams. In internal flues these seams should always be below the grate-plate. The use of welded corrugated tubes in the first two courses is recommended. In externally-heated upper drums only that longitudinal seam, the outer lap which extends upwards, must be exposed to the fire and in such a way that it does not come too close to the masonry; the diametrically opposite seam must be protected by the covering.

Fig. 16.—Long cracks extending through several rivet holes.

Location.—In the circular seams of fire-tubes connected by flanges or by lap joints. Also in the round seams which connect the fire-tube to the end of the drum.

Cause.—Badly-made seams; the absence of a packing ring; too great spacing of the rivets and hard material; finally, on account of great pressure of the tube on the yielding bottom, and defective calking of the seam; over-calking of the packing ring.

Consequence.—The occurrence of large leaks; progressive lengthening of the crack. Breaking loose of the tube is to be feared.

Prevention.—The rivet holes are to be drilled, when the plates are curved and well-fitted together. By the riveting of the circular seams the rivets must be very carefully held on the inside, otherwise the seam is injured. The packing ring must be strong and carefully calked by the American method with a round nose calking-iron. The use of a piece of corrugated tube for fire-tubes of sufficiently large diameter.

Fig. 17.—Cracks in the rivet holes parallel to the edge of the plate in the longitudinal seams.

Location.—On the outer shell of boilers with large diameter. Also together with cracks extending from the rivet hole to the edge of the plate.

Cause.—Too weak single riveting with insufficient strength of the rivets and spacing; or the effect of the flames on exposed longitudinal seams.

Consequence.—Breaking of the plates, under certain conditions with explosion.

Prevention.—All longitudinal seams to be made with double riveting and, when possible, protected from the direct action of the flame. Caution in firing, emptying and filling the boiler. The emptying must be done after drawing the fire and under as small a pressure as possible. Quick cooling of the drum through filling of the boiler with cold water is to be avoided.

Fig. 18.—Cracks along the seams.

Location.—Beside the calked edge, especially at longitudinal seams.

Cause.—Cracking of the plate by hammering when insufficiently heated. Injury to the surface of the plate by bad calking. (Formation of a scratch in the surface.)

Consequence.—Dangerous at the longitudinal seams. Even the shortest crack, extending through the plate, necessitates its replacement.

Prevention.—The metal must not fall below a red heat when worked. Calking of the seams with a round iron is recommended.

Fig. 19.—Cracks in the plates.

Location.—Cracks in a circumferential direction on the fire-plates of externally fired boilers of every sort, mostly cross-cracks without any change of shape at the defective place.

Cause.—Sudden cooling of intensely heated plates by the cracking off of scale; cracks are then formed shortly after heating; want of elasticity in the material; often in mild steel plates.

Consequence.—Outflow of water under pressure; danger of breaking the whole plate. Branch-cracks in steel plates on the fire-side should not be neglected under any circumstances.

Prevention.—Thorough investigation of the plates. Use of the best material. Mild steel plates of too high tensile strength are to be avoided. Repairs with patches are not recommended. Replacing of the entire plate is preferable. Scratches in the material on the water-side should be examined with a file as to softness and depth. Hard plates with scratches are immediately to be renewed. Scratches on the fire-side of the plate are dangerous and quickly destroy the plate.

Fig. 20.—Cracks in corroded places on the inside of the boiler.

Cause.—Too thin through corrosion.

Consequence.—The sudden appearance of considerable leaks: by larger extension emptying of the boiler with explosive violence; very dangerous.

Remedy.—Furrow-shaped corrosions, especially on round seams and of large extent, are to be thoroughly investigated with punch or drill, and their depth to be measured. Repair by renewing the plate.

IV.—Faulty Material. Figs. 21 to 23.

Fig. 21.—Plates imperfect on the surface.

Location.—On any part of the drum-shell, as well on the inside as on the outside, but it is generally developed only on parts exposed to the fire.

Cause.—Unwelded material, due to cold-rolling or to penetration of surface scale during rolling.

Consequence.—The shell is only weakened by large extension or depth of the imperfection.

Prevention.—Only plates of the best quality should be used in boilers, especially for fire flues, and should be thoroughly inspected. Surface scales are to be carefully chiseled away over their whole extent and their depth determined.

Fig. 22.—Imperfections within the material. Open holes (forming of blisters).

Location.—On the fire-side. In all forms of boilers only on the worst heated plates (in or close to the furnace).

Cause.—Bad welding of the material through which uniform heating is hindered and unequal tensions produced, the larger holes appearing mostly in places where the temperature is very high.

Consequence.—Superheating on account of impeded transmission of heat. The defective place becomes red

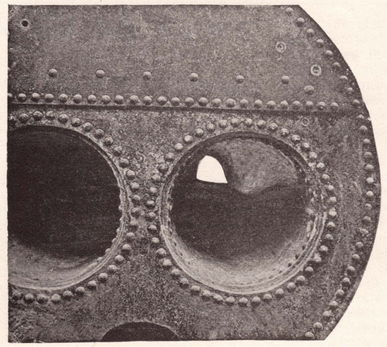


Fig. 27. Buckling Downward of Flue Plate.

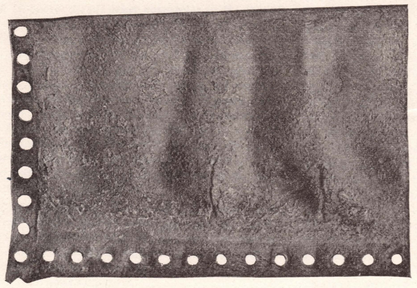


Fig. 28. Plates Cracked by Wave-Shaped Bulges.

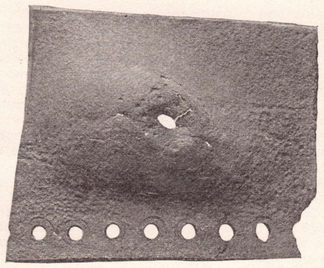


Fig. 31. Ruptures in a Bag or Pocket Bulge.

Fig. 25. Bag or Pocket Bulge.

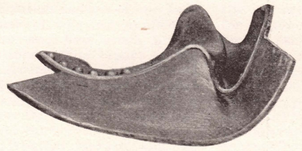


Fig. 26. Inward Buckling at Circumferential Joint.

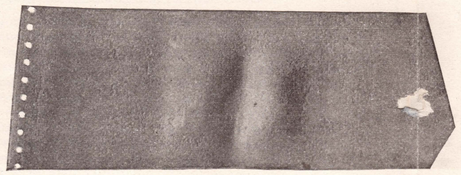


Fig. 24. Wave-Shaped Bulges on Fire Plates.

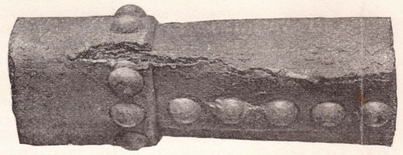


Fig. 30. Longitudinal Crack in a Buckled Flue

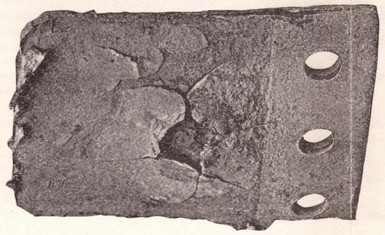


Fig. 29. Rupture at Bulge in a Laminated Plate.

GROUP I. DEFORMATIONS. (FIGS. 24 TO 31.)

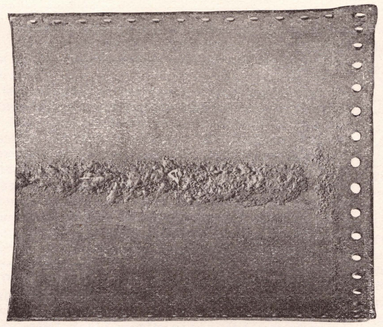


Fig. 44. Internal Corrosion Due to Burning the Plate Above the Water Line.

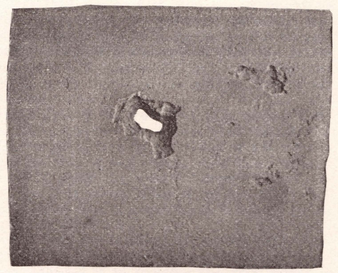


Fig. 41. Deep Pits through a Plate.

Fig. 46. Corrosion of Interior Rivet Heads.

Fig. 42. Deep Pits with General Corrosion.

Fig. 47. Pitting on Water Side of a Tube.

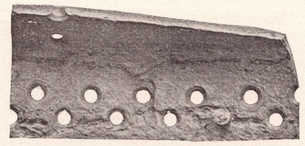


Fig. 45. Grooving at Bend of Sheet.

Fig. 43. A Case of General Pitting.

GROUP III. DEFECTS CAUSED BY INTERNAL CORROSION. (FIGS. 41 TO 47.

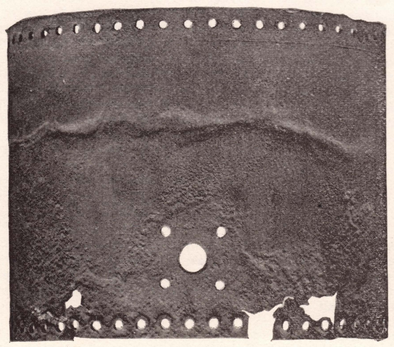


Fig. 36. Examples of Local Rusting.

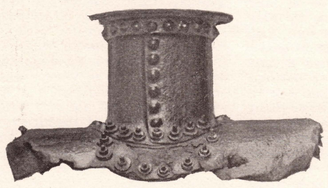


Fig. 39. A Bad Repair Job—Patch Bolted on Inside of Shell.

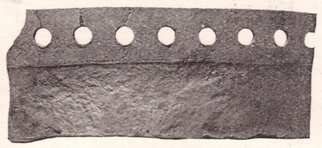


Fig. 32. Corrosion Caused by Leakage Through Seam.

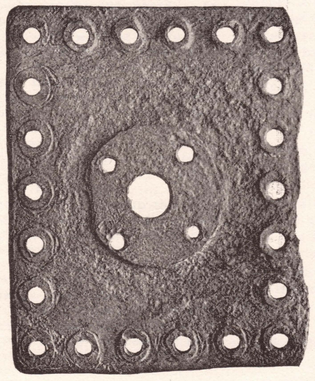


Fig. 38. Corrosion from Leakage around Flange of Steam Pipe Joint.

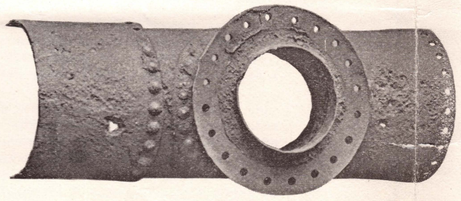


Fig. 40. Corrosions on Vertical Flues.

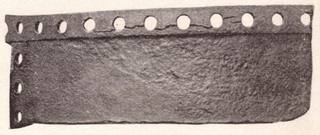


Fig. 33. Corrosion from Leakage Through Cracks between Rivet Holes.

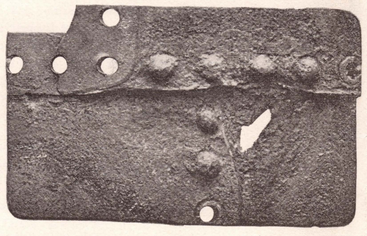


Fig. 37. Example of Rusting at Junction of Joints.

GROUP II. DEFECTS CAUSED BY EXTERNAL CORROSION. (FIGS. 32 TO 40.)

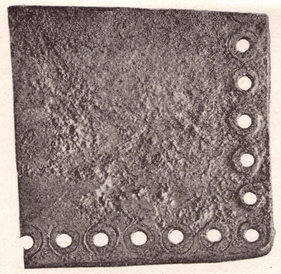


Fig. 35. General Corrosion of a Plate.

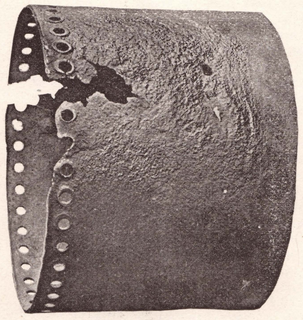


Fig. 34. Corrosion Extending Through Shell.

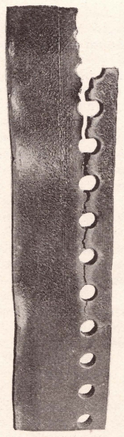


Fig. 51. Crack Through a Seam.

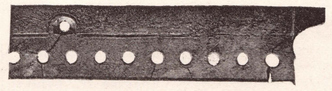


Fig. 50. Cracks Through Rivet Holes and Groove Made by Calker's Chisel.

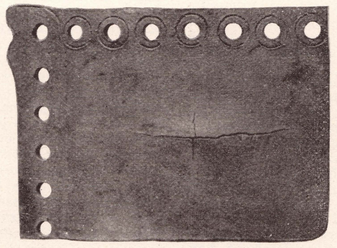


Fig. 52. Through Cracks at an Incipient Bulge.

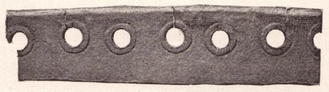


Fig. 48. Short Cracks at Rivet Holes.

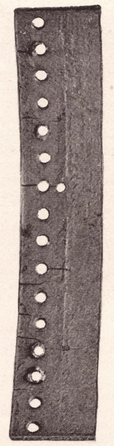


Fig. 49. Cracks Through Rivet Holes and at Edge of Plate.

GROUP IV. CRACKS AND RUPTURES (FIGS. 48 TO 52.

TYPICAL DEFECTS IN STEAM BOILERS.

Collected by a Committee of the Austrian Society of Engineers and Architects.

hot. Considerable weakness in the plate. Burning of the plate on the fire-side. Very dangerous.

Prevention.—Thorough examination of plates before use by careful sounding. For correct sounding it is recommended to divide the plate into squares of 10 cm. (4 ins.) on a side. Imperfect plates are detected by the sound when rubbed on the surface with a stone.

Fig. 23.—Imperfections on the water-side of the tubes of water-tube boilers.

Cause.—Small imperfections owing to impure material.

Consequence.—Not dangerous.

THE STEEL RAIL POOL is dissolved, according to a press dispatch from Pittsburg, on Feb. 9, and prices of rails will now no doubt drop to the lowest figures ever known in the history of the trade. The rail pool has been in existence many years, and has been more successful in holding up prices than probably any other pool that has ever been known in the iron trade. It advanced the price of rails from $22 to $28 per ton between June and September, 1895, on a rising market for iron products in general, and then when the general market fell it continued to hold the price of rails at $28 for 15 months, or until December, 1896, when it reduced it to $25. It is now stated that the Lackawanna Steel Co. withdrew from the pool last week, giving as a reason that other members had cut the price below $25 per ton, and it at once began to seek orders at $20 per ton. The Lake Shore & Michigan Southern R. R. is said to have contracted with the Illinois Steel Co. for 5,000 tons of rails at $21 in Chicago, which is equal to $19 a ton in Pittsburg. How successful the steel rail mills have been in maintaining prices is shown by the following comparison of average annual prices of Bessemer pig iron, steel billets and steel rails since 1888. There has never been any pool of makers of pig iron, and none in steel billets, except the short-lived one which lasted for eight months in 1896, and then went to pieces, so that the prices of pig and of billets may be taken as normal prices in a free market, the difference between them representing approximately, except in 1896, the difference in cost, while the difference between the prices of billets and rails represents approximately the profits per ton which the steel rail men were enabled to make by reason of their pool:

Average Pittsburg Prices of Pig Iron, Billets and Rails.

Year.	Bessemer pig.	Steel Billets.	Steel Rails.	Difference between Pig and billets.	Difference between Pig and rails.	Difference between Billets and rails.
1888.....	$17.38	$28.78	$29.83	$11.40	$12.45	$1.05
1889.....	18.00	29.45	29.25	11.45	11.25	.20
1890.....	18.85	30.32	31.75	11.47	12.90	1.43
1891.....	15.95	25.32	29.92	9.37	13.97	4.60
1892.....	14.37	23.63	30.00	9.26	15.63	6.37
1893.....	12.87	20.44	28.12	7.57	15.25	7.68
1894.....	11.38	16.58	24.00	5.20	12.62	7.42
1895.....	12.72	18.48	24.33	5.76	11.51	5.85
1896.....	12.09	19.33	27.75	7.24	15.66	8.42
Feb., 1897...	10.50	16.00	20.00	4.00	8.50	4.00

The average difference between rails and billets for the six years, 1891 to 1896, inclusive, was $6.72. The figures for the three years, 1888, 1889 and 1890, showed that rails could be sold at an average of less than a dollar a ton above the price of billets, leaving say $5.72 per ton as the average extra profit, which the pool enabled the steel rail men to make. As during these six years their sales were in the neighborhood of 7,500,000 tons, this represents a profit of $40,000,000.

If steel rails can be made almost as cheaply as steel billets, provided large orders are obtained for one size at a time, there would seem to be no reason why they cannot be sold at a profit at $17 per ton at Pittsburg, when the price of pig iron is $10.50. If they should fall to this price, it should encourage the railways to make extensive purchases, and give the stimulus to business of which the country now greatly stands in need.

THE EXHIBITION OF THE WORK OF GRADUATES of the Stevens Institute of Technology, Hoboken, N. J., which will be held on Feb. 19, as already announced in these columns, promises to be a most attractive feature of the 25th anniversary celebration of the Institute. The applications for space indicate that the exhibit will be a large one and most varied in character. One of the graduates, Mr. Lewis P. Nash, class of 1877, bears the distinction of being among the five most prolific inventors of the United States, over 200 patents having been issued to him on water meters, gas engines, and their various details. He will exhibit a complete electric ight plant run by a gas engine. Much of the work of the graduates will be illustrated by photographs, working drawings, etc., of works carried out. The exhibition will be open to the public and will doubtless be largely attended by engineers.

A STEEL PLANT IS TO BE BUILT AT BIRMINGham, Ala., at last, according to a brief statement in the "Iron Age," which says that the capital will be $300,000, that the plant, therefore, will not be a large one, but "it will be ample to furnish more steel than the rolling mills want." If the wants of the rolling mills are to be the measure of the capacity of the new Southern steel works, we fear there is a poor outlook for it. The kind of steel works which the south needs is one which not only has its own rolling mills but its own plant for finishing its product into shape ready for final consumption. If it has to ship its partly finished material in the shape of ingots, blooms, etc., to other mills and plants to be finished it will probably find Pittsburg a most dangerous competitor.

THE LARGEST HYDRAULIC CYLINDER ever made in this country has recently been finished in the Homestead works of the Carnegie Steel Co. It was made for the large hydraulic press in the armor plate department. The original cylinder of the press, which had been made in England, was in three pieces, and when it broke it was decided to make a new one in one piece. Its dimensions are 11 ft. long and 6 ft. inside diameter, and its finished weight 80,000 lbs. It was made of nickel-steel in a sand moid, the heats of two open-hearth furnaces being required for the casting, which weighed 90 tons in the rough. It was bored in a machine specially built for the purpose, and when the boring was completed it is said that not a blowhole nor blemish was found in it.

THE NEW POST OFFICE AND FEDERAL BUILDING for Chicago will rest on concrete and steel cylinder foundations, according to information made public by the supervising architect, Mr. Henry Ives Cobb, of Chicago, Ill., under whose direction the plans are now being prepared in Washington, D. C. It is stated that the steel cylinders will vary in diameter from 12 ft. to 15 ft. and will be sunk to bed rock 72 ft. below the present surface and filled with concrete. The total estimated cost of the foundations is placed at $200,000, and it is announced that work will begin on them as soon as the ground is cleared from the old building, which is now in process of demolition. The total appropriation for the building is $4,000,000.

THE NEW BICYCLE FACTORY of the Keating Wheel Co., at Middletown, Conn., is interesting on account of its unique construction and of its method of application of motive power. The main building is a 2-story building, 1,000 ft. long and 50 ft. wide, and projecting from it at right angles are six separate shops, each 50 ft. wide, one of them 200 ft. long, two stories high, and the others about 100 ft. long, one story high. A separate building contains the offices, and another the power generating plant. Steam is generated by a 250-HP. Babcock & Wilcox boiler, and is utilized by a Greene cross-compound engine which drives by belt and countershaft a General Electric three-phase generator, known as an A-T 16-pole 250 KW, 450 revolution, 60 cycle machine. Another and similar three-phase generator, for furnishing power current, and a set of lighting machines will later be driven from the same countershaft. All the power is transmitted to the factory in the shape of electric current. The main shafts in the first floor of the main building are about 800 ft. long in all, being divided into three sections, between each of which is a 50-HP. General Electric induction motor suspended from the ceiling. Other lines of shafting in the various shops are driven by smaller motors. All of the motors are equipped with two pulleys on each end so that four independent shafts can be driven from each motor. The factory, when in running order, will be one of the most complete cycle factories in the world. It will be some months before it will be completely equipped with machinery. The company's 1897 wheels are being manufactured at Holyoke, and as soon as any piece of machinery can be dispensed with there it will be moved to Middletown.

A GOOD ROADS BILL introduced in the New York Senate by Mr. Higbie provides for the appointment of a State Highway Commission, to consist of three members, to be confirmed by the Senate, one of whom shall be a civil engineer. They are to serve for three, four and five years, respectively. Each commissioner is to receive $5,000 annual salary, and the commission is to have $10,000 for office expenses annually. The commission is directed to compile statistics regarding the public highways throughout the state, and prepare a map indicating such highways as are of sufficient importance to be subject of state aid. The map must also show where material suitable for road-building may be obtained. The commission is to determine upon the best method of constructing roads, and advise county, city, town or village officers in relation to the matter. Half of the expense of road construction is to be a state charge and the other half a county charge in the first instance. Provision is made for assessing 35% of the expense on the county at large and 15% on the property directly benefited in certain cases. No county can receive more than 5% of the state appropriation in any one year. The State Commission may provide for roads in counties to connect roads already improved. This proposed law provides for the levying annually of a state tax of 1-10 mill, to be known as a state highway tax. The money thus raised is to pay the state's share of the expense of highway improvement. The tax provided in the bill would raise annually $436,000.

THE LEASE OF THE BRAZILIAN GOVERNMENT railways is advertised and bids will be received until May 15 at the General Traffic Department of the Ministry of Industry, Traffic and Public Works, Rio Janeiro, and also at the Brazilian Legations in Washington, London, Paris, Brussels and Berlin. The lease is to be for a term of 60 years. There are eight railways to be included in the lease, as follows: Brazil Central Ry., 755 miles; Baturite Ry., 151 miles; Sobral Ry., 134 miles; Pernambuco Southern Ry., 120 miles; Pernambuco Central Ry., 100 miles; Bahia & San Francisco Ry., 94 miles; Paulo Affonso Ry., 72 miles, and the Porto Alegre & Uruguayana Ry., 364 miles, or 1,790 miles in all.

COPPER SHEATHING FOR PASSENGER CARS is being tried on the New York, New Haven & Hartford R. R. at the suggestion of Mr. W. P. Appleyard, Master Car Builder. The improvement consists in covering with a thin sheet of copper each piece of wood sheathing, paneling, belt rail, etc., that enters into the construction of the exterior of the car, the wood being made thinner to compensate for the weight added by the copper. After the sheathings and other parts are covered they are applied to the body of the car in such a manner that the exposed surfaces are not punctured by nails. The cost of plating a car with copper is said to be less than painting and varnishing it, and a cheaper grade of lumber may be used than that now required. The copper takes a rich bronze tint, in the atmosphere, requiring no further treatment, and the finish is at once simple, beautiful and durable.

AN INTERESTING IMPROVEMENT IN GAS ENGINES has just been patented by Mr. Joseph Ledent, of Baltimore, Md., (Pat. No. 575,720, Jan. 26, 1897,) the object of which is to diminish the heat losses of the engine and increase its efficiency. As is well known in the ordinary gas engine 40 to 50% of the energy of the heat delivered to the engine is lost in heat carried away in the jacket water. Mr. Ledent proposes to substitute for the usual water jacket the injection of a small amount of water at each stroke of a vertical engine, when the piston is at its highest position, into an annular space formed by a groove in the upper portion of the barrel of the piston and the adjoining cylinder wall. When the explosion takes place part of this water will be evaporated into steam at high pressure, and part will remain as a film in the walls of the cylinder, preventing it from becoming overheated. The steam formed by the evaporation of the water does work as in a steam engine, this work representing so much gain from the fuel, as the heat required to evaporate it is heat which in the ordinary gas engine is wasted in the jacket water.

THE WORLD'S DRY-DOCKS NUMBER 622, of which England owns about 56%, with 266 located in England, Ireland and Scotland, and 74 located in England's colonies and dependencies. The other dry-docks are scattered through about 21 other nations. The United States has 63; France, 60; Germany, 32; Spain, 14; Holland, Italy and Sweden, 13 each, and Belgium 11. The Empress dock, at Southampton, is the largest single graving dock in the world; it is 751 ft. long, 88½ ft. wide, and 28½ ft. deep.

MEXICAN RAILWAYS IN 1896, says Mr. Romero in the "Bulletin of the American Geographical Society," aggregated nearly 7,000 miles in length. During 1895-96 Mexico exported precious metals worth $64,838,595; of which $51,071,661 went to the United States. Out of $40,178,306 in commodities exported, $28,580,034 in value went to the United States. But Mexico imported from the United States $20,145,763, out of $42,253,938 total value of imports.

THE STEVENS INSTITUTE OF TECHNOLOGY is an example of what a great amount of work can be done by an educational institution on a comparatively small endowment. The founder of the Institute, Mr. Edwin A. Stevens, in 1870 bequeathed a plot of ground and $150,000 for the erection of a building, together with $500,000 as an endowment fund. From this amount the U. S. government took $45,000 as a collateral inheritance tax, the law imposing such taxes being then in force as one of the "war taxes." As the number of students demanding admission to its courses increased, the Institute was badly hampered by the lack of funds to provide room, equipment and instructors for them. The President of the Institute, Dr. Henry Morton, several years ago presented $10,000 to the trustees with which to equip a new machine shop, and more recently has made other contributions to help increase the facilities. He has now made a new donation to the trustees of 1,000 shares of Texas Pacific R. R. Co. stock, worth to-day $10,000, but expected to increase in value in a few years, on account of the intrinsic value of the property it represents. This stock will be added to the fund started some years ago by the Alumni Association for the erection and maintenance of a new laboratory building, work upon which, it is hoped, will soon be begun. President Morton has succeeded in securing the following speakers for the anniversary dinner, which is to be held at the Waldorf on the evening of February 18: Bishop Potter, Andrew Carnegie, Professor James E. Denton, Governor Griggs of New Jersey, President Seth Low, Vice-president-elect Garret A. Hobart, C. F. Chandler, of Columbia; Mayor Strong, ex-Mayor Hewitt, Commodore Melville, U. S. N., and Mayor Fagan, of Hoboken.